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Efficacy of edible coatings blended with aloe vera in retaining post-harvest quality and improving storage attributes in Ber (*Ziziphus mauritiana* Lamk.)

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Abstract
Efficacy of chitosan, gum acacia, guar gum, and paraffin is well established as an effective edible coating. To ensure combined benefits of edible coating and medicinal herb, an attempt has been made to blend these two into a homogeneous mixture and use it for quality enhancement studies of ber. Gaur gum blended with aloe vera could reduce physiological loss in weight (9%) upto 15th day of storage. Shrinkage percentage in terms of length and breadth was minimum in T_3 which was 1.96 and 2.55 respectively. Guar gum blended with aloe-vera was also able to maintain the greenish-yellow colour of the fruit upto 15th day of ambient storage and was able to minimize the loss in titratable acidity as well. Guar gum blended with aloe-vera was also able to restore ascorbic acid content upto an extent. Fruit firmness was also more upto 15th days (657.67 N) of storage when the fruits were coated with guar gum blended with aloe-vera. Minimum decay of fruits were observed in T_3 (1.67) followed by T_6 (6.67), T_9 (6.69), T_8 (8.33) and T_2 (8.33).

Keywords: *Aloe vera*, edible coating, blended edible coating, guar gum, ber, chitosan

Introduction
Ber is an established fruit crop in semi-arid regions and is even commercially grown in subtropical regions. Ber is botanically *Ziziphus mauritiana* Lamk and is the member of family Rhamnaceae. Ber is a vital fruit with respect to its distinct processing attributes. It is admirable source of minerals, natural antioxidants and is having antimicrobials properties as well. Ber is basically a fruit of climacteric nature and the physiological processes like ripening and senescence is triggered by exogenous ethylene supply. The consequence is very less storage life and the fruit is prone to softening, skin browning and fruit decay. According to Meena *et al*. 2009 [14], ber fruit is having high perishability and usually have a poor storage life of only 2-4 days at ambient storage conditions. Ber is a seasonal fruit and is available in the market for only a few weeks. So naturally there is superfluous availability of fruits in the markets during peak fruiting season. Farmers don't get enough price for the fruits they are selling in the peak fruiting season. Increase in the availability of the fruit in the market can fetch a better price. A quite substantial portion of the total fruits are not reaching consumer hand and are wasted rendering a havoc postharvest loss. Diversified approaches can be implemented that includes refrigeration, modified atmosphere storage (MAP), use of chemical preservatives and suitable packaging practices to diminish such qualitative and quantitative losses (Zhang and Quantick, 1997) [31]. Edible coatings and films are a much cheaper alternative when compared with the other expensive techniques that are seldom used in shelf life extension of fresh produce (Baldwin *et al.,* 1995). Efficacy of edible coatings in fruits and vegetables has long been documented as an approach to prevent perishable food products from deterioration upto a considerable extent (Debeaufort *et al.,* 1998) [5]. Edible films basically are the primary packaging which is prepared from edible materials (Melvin and Shin, 2012) [15]. Edible coatings are known to offer a hindrance against outer elements and consequently it increases the shelf life (Guilbert *et al*., 1996). This feature can be accomplished by reducing the gaseous exchange, reducing the loss of water, prevent flavors and aroma losses and retard solute relocation towards the cuticle. Del-Valle *et al*. 2005, have reported the efficiency of different types of edible coatings in reducing the loss of volatile compounds, holding back moisture

migration, decreasing the rate of respiration and delay the catabolic changes in textural attributes. Edible films and coatings are acknowledged as they endow fresh fruits with a supplement arydefensive coating. Similar circumstance of a modified atmosphere system of package can be imagined in case of an edible coated fruit or vegetable (Park *et al*., 1994) [19]. A very thin coating layer of edible material usually prevents the desiccation of fruit, uptake of oxygen and loss of other volatile material from inside the fruit (Lowe *et al*., 1963; Lachman *et al*., 1986) [12, 11]. Edible coatings are also effective as an important preservation practice of horticultural produce due to its barrier properties against gas, moisture and solute molecules between the system (fruit tissues) and the outside surrounding. The best thing with edible coatings is that these coatings can be eaten with the food product with no health problems (Anand *et al*., 2007) [1]. Aloe vera is known to have excellent anti-bacterial property owing to its alloin content. Aloe vera gel is an exceptional edible coating material for fruits and vegetables owing to its great antifungal activity (Kumar and Bhatnagar, 2014) [10]. Aloe vera is a well-established medicinal plant and is valued for its diverse beneficial therapeutic qualities. *Aloe vera* is an established medicinal herbaceous plant with diverse utilities and are being used since historic times. Aloe vera is also called as multipurpose-purpose herbal plant because of its multifarious application in ayurveda, cosmetic industry and pharmacy. Two foremost liquid composition of *Aloe vera* are a clear mucilaginous gel and yellow latex (Ni *et al*., 2004) [18]. The new trend is using such natural medicinal herbs as a safer option to expand the shelf life of delicate and perishable fruit crops. Efficiency of Aloe vera gel has been long renowned as a brilliant edible coating with good antimicrobial properties as well (Jasso *et al*., 2005; Valverde *et al*., 2005; Mani *et al*., 2017) [20, 26, 6, 13]. *Aloe vera* gel was able to inhibit the growth and expansion of both gram positive and gram negative bacteria (Habeeb *et al*., 2007) [7]. Shelton *et al*. (1991) [23] reported that Aloe vera gel expressed good anti-bacterial action and was equally effective against some food-borne pathogens including *Escherichia coli, Salmonella typhimurium*, *Bacillus cereus and Klebsiella pneumoniae*. Aloe vera has successfully earned its position in the post-harvest and food industry as an important resource of functional foods in ice-cream, drinks and beverages (Moore and MacAnalley, 1995) [17]. Due to an excellent antifungal property of Aloe vera gel, it is quite an exclusive edible coating either used solely or in blended combination with other components. Mani *et al*. (2017) [6, 13] while working with ber cv. Umran found that aloe-vera can help to lengthen the ambient shelf life of ber upto 15 days at an optimum level. Ghosh *et al.* (2017) [6] while working on edible coating of Indian olive found out that application of guar gum coating could be beneficial in prolonging the postharvest life, maintaining fruit quality and antioxidant content (ascorbic acid) of Indian olive fruits. Literature search revealed absence of Aloe vera blended edible coating studies in ber. Hence, the study was undertaken to estimate the efficiency of edible coatings blended with Aloe vera to extent the ambient shelf life of ber.

Materials and Methods

Location and site: Fully matured, uniform size ber c.v. Umran were collected from farmer's orchard, Coochbehar, Bengal in 2017 fruiting season. The fruits were harvested fresh during the month of February. It was ensured that the fruits harvested are of uniform maturity, free of any blemishes and were immediately brought to the PG laboratory, Department of PPHT, UBKV, Coochbehar, Bengal for necessary treatments. The fruits were properly washed and cleaned in running tap water and then were dried in the shade for few minutes. After this, the fruits were then treated with different types of edible coating according to the treatment combinations below.

Treatment details and formulation: A set of 60 fruits with 20 fruits per replications were taken. Total 3 replications were performed per treatment. Edible coating of the fruits was done using the following treatments.T_1-Control, T_2-Guar gum @2%, T_3-Aloe vera gel @2% + Guar gum @2%, T_4-Paraffin @5%, T_5-Aloe vera gel @2% + Paraffin @5%, T_6-Chitosan @2%, T_7-Aloe vera gel @2% +Chitosan @2%, T_8-Gum arabia/acacia @2% andT_9-Aloe vera gel @2% + Gum arabia/acacia @2%. All the edible coating materials were of analytical quality. Gum solutions were prepared by heating in oven and then cooling in air (Wijewardane *et al*., 2013) [29]. Chitosan solutions were prepared according to Jiang and Li (2001).Gum tragacanth powder was used in ratio of 10 to 100 ml (w/w) and was then mixed in water. The system was stirred and then kept in the refrigerator for 24 hours to ensure uniform mixing (Mohebbi *et al*., 2012) [16]. For preparing 500 ml of 2% (w/v) chitosan solution, 5.0 g of chitosan were accurately weighed and were then dispersed in 50 ml of glacial acetic acid. The pH of the particular solution was attuned to 6.0 with addition of 1M NaOH and then the solution was volume made up to 500 ml.

Preparation of edible coating solution: Fresh and healthy leaf of Aloe vera was cut transversely to extract out the hydroparenchyma. The hydroparenchyma was filtered properly to separate out fibres and unwanted liquids. The consistent mucus obtained was the fresh Aloe vera gel. The matrix thus obtained was subjected to heat at 70^{O}C for 45 minutes. After that the gel was cooled for sometimes. Around 1 ml of ascorbic acid was added.

Application of the edible coating solutions: Fresh fruits after proper cleaning were properly dipped in the arranged coating solutions for about 5 minutes. The fruits were revolved and rotated so as to increase the coating efficiency. The extra coating was allowed to drain out for 2 minutes. After this, the coated fruits were allowed to dry up at room temperature. After proper drying, weights of the different coated fruits were chronicled. A set of exactly 25 fruits was taken for coating treatment in each replication.

Physiological loss in weight (PLW): This can be analyzed by weighing both the coated and uncoated fruits during their ambient storage. Basically, the loss in weight is due to water loss from the fruit tissue. So water loss was calculated by using the equation:

$$\frac{\mathrm{PLW}}{\mathrm{Water}}\,\mathrm{loss}\ (\%) = \frac{\mathrm{Wo}-\mathrm{Wf}}{\mathrm{Wo}} \times 100,$$

Where, W_o is initial weight of fruits (at 0 day) and W_f is final weight of fruits.

Shrinkage percentage: The length and breadth of ber fruits (millimeter) were measured as a key for determining shrinkage percentage. Length and breadth was measured by using digital Vernier calipers.

$$\text{Shrinkage percentage in terms of length} = [(\text{initial length} - \text{final length}) / \text{initial length}] \times 100$$

$$\text{Shrinkage percentage in terms of breadt} = [(\text{initial breadth} - \text{final breadth}) / \text{initial length}] \times 100$$

Fruit Colour: The colour of the fruits was chronicled with the aid of Royal Horticulture Society colour chart (Fifth edition, 2007).

Bio-chemical analysis of coated fruits: Total soluble solids (TSS) content of fruits were determined by putting drop of liquid fruit extract in digital refractometer. Total sugar and reducing sugar content were judged by the methodology of Mazumdar and Majumder, 2003. The acidity and ascorbic acid were assessed by the method designated by Rangana. pH of the ber fruit samples were resoluted as per the method of AOAC (1994).

Degree and rate of fruit spoilage: The rate/degree of spoilage were determined by visually observing the coated and uncoated fruits forfungal growth. The number of fruits affected or rotten was recorded once in a while to assess the consequence of the different coating treatments on fruit spoilage percentage.

Texture or fruit firmness: Instrumental texture analyzer (Stable Microsystem; Model: TA. XT. Plus) in CIC laboratory, UBKV was used for this experiment. A 2 mm probe was used in this experiment. The test speed was set at 2 mm/second and trigger force at 5 g. The sample was kept on the tray and the probe was allowed to penetrate the sample. A graph was obtained on the screen. The force in gram (g) values corresponding to the highest peak was noted. Penetration force was presented as hardness in N (newton).

Statistical tool: The design of the study is Randomized Block Design consisting of three replicates. The data presented in this paper was statistically analyzed by SPSS 23 software and the mean and standard deviation (SD) were calculated.

Results and Discussions

Physiological loss in weight: Physiological loss in the weight is a common incidence in all the treatments as the storage period proceeded (Table 1). The physiological loss in weight was maximum in case of T_1 (control) which was 19.67%. Minimum physiological loss in weight was observed in T_3 (Aloe vera gel @2% + Guar gum @2%) and T_2 (Guar gum @2%) which was 9%. The weight loss of the coated and uncoated fruit was mainly concomitant with the forfeiture in water from the fruit tissues and water use up during respiration. According to Hernandez *et al*. (2008) water loss is because of the water concentration gradient inside the fruit and outside environment. According to Yamanand, (2002) [30]; water loss from fruits only takes place in vapour pressure deficit outside the fruit is more as compared to that of the inside. Reduction in loss of weight loss was mainly due to the partial barrier of the coating materials to oxygen (O_2), carbon dioxide (CO_2), moisture (H_2O) and solute migration.

Table 1: Effects of edible coatings on Physiological loss in weight (%)

Treatments	Days after storage		
	5th day	10th day	15th day
T_1 (Control)	18.33	20.67	19.67
T_2 (Guar gum @2%)	12.07	10.67	9.00
T_3 (Aloe vera gel @2% + Guar gum @2%)	9.13	9.67	9.00
T_4 (Paraffin @5%)	14.33	14.67	16.33
T_5 (Aloe vera gel @2% + Paraffin @5%)	15.33	13.67	12.67
T_6 (Chitosan @2%)	15.33	15.67	14.67
T_7 (Aloe vera gel @2% +Chitosan @2%)	13.67	14.67	13.00
T_8 (Gum arabia/acacia @2%)	14.67	14.67	15.67
T_9 (Aloe vera gel @2% + Gum arabia/acacia @2%)	15.67	14.33	14.67
SE m. (±)	0.42	0.53	0.45
C.D. at 5%	1.28	1.60	1.37

Shrinkage percentage: Table 2 represents the shrinkage percentage of the treated and untreated ber fruits in terms of length and breadth. Clearly it can be observed that the change in length is maximum in T_1 (control) which is 20.4 mm at day 5, 19.53 at day 10th and 19.0 mm at 15th day of storage. Similarly, change in the breadth was also observed maximum in control from 12.17 mm at 5th day to 11.97 mm at 10th day and 11.63 at 15th day of storage. T_3 shows minimum change in length and breadth (mm) followed by T_2. T_3 shows minimum change in length which was 20.17mm in day 5 to 19.9 mm in day 15. Changes in breadth observed the same trend in T_3. Breadth of fruit changed from 12.83 mm in day 5th to 12.6 mm in day 15.

Table 2: Effects of edible coatings on length and breadth (mm) of fruits

Treatments	Days after treatment							
	0 day		5th day		10th day		15th day	
	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth
T_1 (Control)	20.80	12.43	20.40	12.17	19.53	11.97	19.00	11.63
T_2 (Guar gum @2%)	20.90	13.17	20.63	13.00	20.33	12.83	20.13	12.67
T_3 (Aloe vera gel @2% + Guar gum @2%)	20.33	12.93	20.17	12.83	20.03	12.73	19.90	12.60
T_4 (Paraffin @5%)	20.87	13.13	20.47	12.93	20.23	12.83	20.07	12.57
T_5 (Aloe vera gel @2% +Guar gum @2%)	19.80	12.90	19.53	12.63	19.27	12.50	19.00	12.23
T_6 (Chitosan @2%)	19.80	13.03	19.47	12.77	18.90	12.60	18.60	12.30
T_7 (Aloe vera gel @2% +Chitosan @2%)	20.50	12.83	20.13	12.60	19.57	12.37	19.27	12.13
T_8 (Gum arabia/acacia @2%)	19.60	13.10	19.33	12.90	19.00	12.63	18.83	12.40
T_9 (Aloe vera gel @2% + Gum arabia/acacia @2%)	20.77	12.93	20.40	12.70	19.93	12.40	19.73	12.33

SE m. (±)	0.62	0.16	0.61	0.13	0.63	0.12	0.57	0.12
C.D. at 5%	NS	NS	NS	0.41	NS	0.36	NS	0.37

From table-3 it can be clearly observed that the shrinkage percentage in length was maximum in case of T_1 (8.65%) and minimum in T_3 (1.96%). Maximum shrinkage in terms of breadth was observed T_1 which is 6.43%. In terms of length T_2, T_4 and T_8 also showed a very low shrinkage percentage of 3.68, 3.83 and 3.93 respectively. Shrinkage percentage in terms of breadth showed a similar trend.

Table 3: Effects of edible coatings on Shrinkage percentage

Treatments	Shrinkage percent (%)	
	Length	**Breadth**
T_1 (Control)	8.65	6.43
T_2 (Guar gum @2%)	3.68	3.79
T_3 (Aloe vera gel @2% + Guar gum @2%)	1.96	2.55
T_4 (Paraffin @5%)	3.83	4.26
T_5 (Aloe vera gel @2% +Guar gum @2%)	4.04	5.19
T_6 (Chitosan @2%)	6.06	5.60
T_7 (Aloe vera gel @2% +Chitosan @2%)	6	5.46
T_8 (Gum arabia/acacia @2%)	3.93	5.34
T_9 (Aloe vera gel @2% + Gum arabia/acacia @2%)	5.01	4.64

Changes in colour of fruits: Table 4 displays the alteration in colour of the coated and uncoated fruits when subjected to different coating treatments. At the time of harvesting, the fruit colour stood yellowish green (YGG150B) in color, which was ultimately transformed in to brown (BG200D) in T_1 and T_4; grayish brown (GBG199C) in T_5, T_6 and T_8; yellow green (YGG145B) in T_2, T_3, T_7 and T_9. A quicker senescence was observed in fruits under control from 5th day of storage. Coated fruits showed a lesser loss in chlorophyll, lesser development of xanthophyll and reduced rate of ripening. It was probably due to an increase in CO_2 and decrease in O_2 levels, which decrease ethylene synthesis followed by delay in colour changes (Buescher). Similar finding by Castricini *et al*. (2012) [4] was that matured papaya fruits coated with carboxymethyl starch and cassava starch abetted the colour during storage. T_3, T_7, T_9 and T_2 showed minimum colour degradation. At 15th day of storage, the yellowish green colour was maintained. The effect was indisputably due to combined effect of coating and Aloe vera blended with it.

Table 4: Effects of edible coatings on colour of fruits

Treatments	Days after storage			
	0 day	**5th day**	**10th day**	**15th day**
T_1 (Control)	YGG150B	YGG144D	GBGN199B	BG200D
T_2 (Guar gum @2%)	YGG150B	YGG144B	YGG144B	YGG145B
T_3 (Aloe vera gel @2% + Guar gum @2%)	YGG150B	YGG144B	YGG144B	YGG144B
T_4 (Paraffin @5%)	YGG150B	YGGN144C	YGG144C	BG200D
T_5 (Aloe vera gel @2% + Paraffin @2%)	YGG150B	YGGN144C	YGG144C	GBGN199B
T_6 (Chitosan @2%)	YGG150B	YGGN144C	YGG144B	GBGN199C
T_7 (Aloe vera gel @2% +Chitosan @2%)	YGG150B	YGGN144C	YGG144B	YGG144B
T_8 (Gum arabia/acacia @2%)	YGG150B	YGG144B	YGGN144C	GBGN199B
T_9 (Aloe vera gel @2% + Gum arabia/acacia @2%)	YGG150B	YGG144B	YGGN144C	YGG144B

GBG- GREY BROWN GROUP, YGG- YELLOW GREEN GROUP, BG- BROWN GROUP

pH value: Table 5 demonstrates pH of ber fruits subjected to different edible coating treatments and stored under ambient conditions. There was a plodding upsurge in pH over storage spell. However, at 5th day of storage, change in pH of the fruit is non-significant at 5% level. pH increased abruptlyat 15th day of storage as compared to 0 day. At 15th day, less pH values were observed in the coated fruit than that of the control fruit. T_3 (Aloe vera gel @2% + Guar gum @2%) showed the minimum pH (5.71) at 15th day of ambient storage. Coating reduces the respiratory and rate of metabolism considerably. At 15th day of storage, the maximum increase in pH value was in fruit samples which had not been subjected to any edible coating which was 5.87. Minimum change in the pH value was observed in T_3 (Aloe vera gel @2% + Guar gum @2%) which was 5.71.

Titratable acidity: Table 5 depicts the change in titratable acidity of the fruits gradually in ambient storage. The fall in titratable acidity was highest in case of control which was 11.47 at 0 day to 8.1 at 15th day of storage. The reduction in acidity content was however lowest in case of coated fruit samples as compared to the uncoated ones. At 15th storage day, lowest fall of acidity was observed in T_3 which was 9.57 followed by T_4 which was 9.33, T_2 which was 9.33 and T_5 which was 9.23. Maximum reduction in acidity was observed in T_1-Control sample which was 8.1 followed by T_6 which was 8.43.

A steady decrease in titratable acidity occurred in both treated and untreated ber fruit throughout the storage period. The apparent reason for decline in the titratable acidity may be the utilization of the organic acids in the respiration and metabolic processes of the fruit. Organic acids gets converted to sugars and further gets exhausted up in the metabolic process of the fruit, due to which there is a decline in acidity (Srinivasa *et al*., 2002) [24]. Both coated and uncoated fruit, showed a decrease in titratable acidity with the passage of storage period (Vyas *et al*., 2014) [27]. Results of the research clearly confirm that the titratable acidity of the control fruits were significantly lower as compared to that of coated fruits. At 10th and 15th day of storage, the higher values of the titratable acidity were observed in the fruits coated with Aloe vera gel coating. The consequences of this study are in accordance with that of Debeaufort, (1998) [5]. It can be concluded that edible coatings reduce the respiration rate and is supposed to delay the utilization of organic acids as well.

Table 5: Effects of edible coatings on pH, titratable acidity and ascorbic acid content (mg/100g)

Treatments	pH				Titratable acidity				Ascorbic acid			
	0 day	5th day	10th day	15th day	0 day	5th day	10th day	15th day	0 day	5th day	10th day	15th day
T_1 (Control)	5.13	5.33	5.74	5.87	11.47	11.00	9.63	8.10	82.07	75.44	72.52	67.93
T_2 (Guar gum @2%)	5.13	5.33	5.61	5.74	11.70	11.47	11.13	9.33	83.57	80.27	77.31	74.94
T_3 (Aloe vera gel @2% + Guar gum @2%)	5.16	5.36	5.58	5.71	11.50	10.93	10.67	9.57	85.57	87.52	86.53	84.41
T_4 (Paraffin @5%)	5.12	5.32	5.72	5.83	11.90	11.63	11.30	9.33	83.90	77.87	79.29	75.22
T_5 (Aloe vera gel @2% + Paraffin @5%)	5.14	5.34	5.67	5.78	11.97	11.67	11.20	9.23	85.43	83.23	81.83	77.82
T_6 (Chitosan @2%)	5.14	5.34	5.69	5.81	11.57	11.17	10.77	8.43	84.87	81.67	80.44	76.43
T_7 (Aloe vera gel @2% +Chitosan @2%)	5.15	5.36	5.62	5.74	11.80	11.53	10.90	8.73	86.37	78.67	75.45	71.44
T_8 (Gum arabia/acacia @2%)	5.18	5.39	5.68	5.82	11.87	11.57	11.00	8.97	85.30	80.63	79.27	75.32
T_9 (Aloe vera gel @2% + Gum acacia @2%)	5.14	5.35	5.70	5.83	11.97	11.50	10.87	8.67	84.03	79.57	78.00	74.05
SE m. (±)	0.01	0.02	0.004	0.006	0.21	0.21	0.20	0.25	2.33	2.06	1.61	1.64
C.D. at 5%	NS	NS	0.01	0.02	NS	NS	0.62	0.74	NS	6.22	4.87	4.96

Table 6: Effects of edible coatings on total sugar, reducing sugar and TSS (O Brix)

Treatments	Total sugar				Reducing sugar				TSS (O Brix)			
	0 day	5th day	10th day	15th day	0 day	5th day	10th day	15th day	0 day	5th day	10th day	15th day
T_1 (Control)	8.26	9.34	10.45	11.51	1.97	2.90	3.75	4.55	6.37	7.43	8.80	10.28
T_2 (Guar gum @2%)	8.28	9.45	10.56	11.62	2.04	3.15	4.06	4.88	6.66	7.42	8.81	10.29
T_3 (Aloe vera gel @2% + Guar gum @2%)	8.37	9.76	10.86	11.93	1.97	3.23	4.21	5.13	6.59	7.97	9.36	10.83
T_4 (Paraffin @5%)	8.29	9.59	10.69	11.76	1.95	2.92	3.85	4.72	6.54	7.56	8.95	10.43
T_5 (Aloe vera gel @2% + Paraffin @5%)	8.25	9.61	10.73	11.80	2.03	3.09	4.02	4.87	6.67	7.65	9.04	10.54
T_6 (Chitosan @2%)	8.24	9.51	10.61	11.65	2.05	3.07	3.96	4.80	6.36	7.37	8.71	10.21
T_7 (Aloe vera gel @2% +Chitosan @2%)	8.32	9.66	10.75	11.81	2.03	3.07	4.03	4.89	6.62	7.76	9.10	10.61
T_8 (Gum arabia/acacia @2%)	8.30	9.54	10.63	11.69	2.05	3.09	4.04	4.91	6.47	7.63	8.98	10.48
T_9 (Aloe vera gel @2% + Gum acacia @2%)	8.35	9.66	10.75	11.81	2.02	3.01	3.97	4.88	6.55	7.45	8.79	10.30
SE m. (±)	0.13	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.13	0.11	0.12	0.12
C.D. at 5%	NS	0.08	0.05	0.06	NS	0.1	0.09	0.1	NS	0.34	0.35	0.36

Ascorbic acid (mg/100g): Table 5 represents the dynamics in ascorbic acid content of the coated and uncoated fruit samples during ambient storage. A very slow decline in the ascorbic acid content of both the coated and the uncoated fruits were observed. The decline in ascorbic acid content in the fruits was more drastic in case of uncoated fruits. T_1(control)showed decline in ascorbic acid content from 82.07 mg/100 g to 67.93mg/100 g. Minimum decline in ascorbic acid content was observed in T_3 where ascorbic acid content declined from 85.57 mg/100 g in 0 day to 84.41mg/100 g.

Total sugar (%): Table-6 shows the increase in total sugar content of the fruits during the storage period. The total sugar content in untreated fruits showed an increase as the storage duration is prolonged. In control sample, total sugar content increased from 8.26 at day 0 to 11.51 at 15th day of storage. The treated samples showed a lesser decline in the total sugar content. Minimum fall in total sugar content was observed in T_3 (Aloe vera gel @2% + Guar gum @2%) which was 8.37 in day 0 to11.93 in day 15.However there was no significant effect of treatment on the total sugar content of the fruits. The increase in total sugar content is dependent of the type of edible coating treatment employed. The increase in total sugar content can be attributed to the fact that starch gets transformed to sugar during the storage period. The noteworthy surge in total sugars content during their storage is credited to the proliferation in the enzymatic activity accountable for starch hydrolysis and sugar breakdown due to respiration. According to Campestre *et al*. (2002), polysaccharides get transformed into soluble disaccharides or mono saccharides through the hydrolytic breakdown of polysaccharides. There was a substantial intensification in total sugar content of fruits at 15th day of storage. The reasons for this may be attributed to the fact that in the commencement of the trial ber fruit was in matured stage. At this stage, the rate of metabolic activities remains significantly low. As the storage period prolongs and ripening is triggered, it led to a significant increase in the levels of sugars.

Reducing sugar (%): Table-6 shows the alteration in reducing sugar content of the treated fruits. There was an increase in reducing sugar content over storage period. The effect of edible coating was seen prominent in retaining the reducing sugar content of the treated fruits as well. At 15th day of storage, loss in reducing sugar content was found lesser in T_3 (5.13%) followed by T_8 (4.91%) and T_7 (4.89%).

Total Soluble Solids (OBrix): Table 5 shows the TSS content of different fruits coated with various types of edible coating materials when stored under ambient storage conditions. There is a steady increase in the TSS content of both the treated and untreated fruits. TSS also followed the same trend as that of the total and reducing sugar. Maximum TSS at 15th day of storage was observed in T_3 (10.83%) followed by T_7 (10.61%), T_5 (10.54%) and T_8 (10.48%).

Texture or Firmness (Newton 'N'): Table 11 shows the texture or firmness of the coated and uncoated fruit samples during their storage period. Decline in the fruit firmness were observed in both the coated and uncoated fruits in ambient storage. The decline of hardness was mainly due to the dissolution of the polysaccharides like xyloglucan, cellulose and pectic substances in the cell wall's middle lamella. The maximum decline in fruit firmness was observed in T_1 (control) which was 423.33 N. T_3 showed the minimum decline in fruit firmness followed by T_2 which was 657.67N and 602.67N respectively. This can be due to the fact that guar gum can retard transpiration and also reduce respiration rate upto a considerable extent.

Table 7: Effects of edible coatings on firmness/hardness

Treatments	Days after storage			
	0 day	5th day	10th day	15th day
T_1 (Control)	900.09	771.67	666.33	423.33
T_2 (Guar gum @2%)	861.86	818.67	702.00	602.67
T_3 (Aloe vera gel @2% + Guar gum @2%)	811.04	787.95	751.00	657.67
T_4 (Paraffin @5%)	881.17	810.67	621.33	506.33
T_5 (Aloe vera gel @2% + Paraffin @2%)	819.41	753.40	584.00	498.00
T_6 (Chitosan @2%)	867.09	776.67	623.67	494.33
T_7 (Aloe vera gel @2% +Chitosan @2%)	791.96	699.00	554.33	505.33
T_8 (Gum arabia/acacia @2%)	774.16	664.67	548.00	481.33
T_9 (Aloe vera gel @2% + Gum arabia/acacia @2%)	772.37	666.67	539.00	494.67
SE m. (±)	35.9	30.64	26.22	18.05
C.D. at 5%	NS	99.65	79.29	54.57

Decay or spoilage percentage (%)

Table 12 shows the effect of different edible coatings on spoilage percentage of fruits during ambient storage. Maximum decay percentage of fruits was observed in T_1 (control) which is 76.67%. Minimum decay of fruits were observed in T_3 (1.67%) followed by T_6 (6.67%), T_9 (6.69%), T_8 (8.33%) and T_2 (8.33%). A comparatively higher decay percentage were observed in T_4 (15%) followed by T_5 (11.67%) and T_7 (11.67%) respectively. This is because aloe-vera gel is not only capable of reducing the rate of respiration and ripening process but it can significantly retard the growth of bacteria, fungi and molds that is known to cause rotting in fruits. Aloe-vera is known to induce a strong defense system in coated fruits. A similar observation was done by Jawandha *et al*. (2014) who reported that percent spoilage of Baramasi lemon fruits was increased with the extension in storage period due to the weakening of the defense system against fungal attack.

Table 8: Effect of edible coating on the decay or spoilage percentage of fruits

Treatments	Days after storage		
	5th day	10th day	15th day
T_1 (Control)	0.00	3.33	76.67
T_2 (Guar gum @2%)	0.00	0.00	8.33
T_3 (Aloe vera gel @2% + Guar gum @2%)	0.00	0.00	1.67
T_4 (Paraffin @5%)	0.00	0.00	15.00
T_5 (Aloe vera gel @2% + Paraffin @2%)	0.00	0.00	11.67
T_6 (Chitosan @2%)	0.00	0.00	6.67
T_7 (Aloe vera gel @2% +Chitosan @2%)	0.00	0.00	11.67
T_8 (Gum arabia/acacia @2%)	0.00	1.67	8.33
T_9 (Aloe vera gel @2% + Gum arabia/acacia @2%)	0.00	0.00	6.67
SE m. (±)	-	-	11.29
C.D. at 5%	-	-	33.80

Conclusion

By going through all the above facts, it can be concluded that T_3 (Aloe-vera gel @2% + Guar gum @2%) is the best edible coating to delay ripening process and ensure maximum storage life at least upto 15 days. Guar gum blended with aloe-vera could reduce physiological loss in weight (9%) upto 15th day of storage. Shrinkage percentage in terms of length and breadth was minimum in T_3 which was 1.96 and 2.55 respectively. Guar gum blended with aloe-vera was also able to maintain the greenish-yellow colour of the fruit upto 15th day of ambient storage and was able to minimize the loss in titratable acidity as well. Guar gum blended with aloe-vera was also able to restore ascorbic acid content upto an extent. Fruit firmness was also more upto 15th days (657.67 N) of storage when the fruits were coated with guar gum blended with aloe-vera. Minimum decay percentage of the fruits were observed in T_3 (1.67) followed by T_6 (6.67), T_9 (6.69), T_8 (8.33) and T_2 (8.33). Hence, it can be concluded that when Aloe vera is blended with guar gum and used as an edible coating, it gives the best storage life with minimum spoilage and maximum bio-chemical qualities.

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